

SIMULATION AND DEVELOPMENT OF RF SWITCH ON MICROSTRIP
PRINTED CIRCUIT BOARD FOR WIMAX APPLICATION AT 2.4GHZ

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This report is submitted in partial fulfillment of the requirements for the award of
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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN
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BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN, SIMULATION AND DEVELOPMENT OF DEFECTED
GROUND STRUCTURE AS A QUARTERWAVE AT 2 GHZ
BAND

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Specially.....

To beloved and supportive parents,

To my kind brother,

And to all my friends

For their Love, Encouragements, and Best wishes

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ABSTRACT

This thesis present the design, simulation and development of RF switch for WiMAX application at 2.4GHz band. This project is focused on RF Switch designing by using PIN diode. Besides, this project will also use Single Pole Double Throw (SPDT) switch type of the RF switch due to Time Division Duplex which is transmit and receive shared the same frequency. This SPDT switch has three poles where the single pole is connect to the antenna while the double throw will connect to the receiver and transmitter. ADS software will be use for design and simulation then the design will be realized on the FR4 board. Once the prototype has been finish, network analyzer will be used to test it for parameter measurement.

ABSTRAK

Tujuan utama projek ini dijalankan adalah untuk mereka, simulasi dan juga membina suis RF untuk aplikasi WiMAX. Suis ini akan menggunakan PIN diode sebagai suis. Suis ini merupakan SPDT yang mempunyai tiga masukan, satu ke antenna satu ke transmitter dan satu ke receiver. Kaedah menjalankan projek ini ialah melalui simulasi, medium yang digunakan ialah ‘Advanced Design System (ADS)’ daripada Syarikat Agilent. Setelah simulasi siap, seterusnya rekaan ini akan diaplikasikan di atas papan FR4 dan diuji oleh Network Analyzer.

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LIST OF ABBREVIATIONS

SPDT	-	Single Pole Double Throw
SPST	-	Single Pole Single Throw
RF	-	Radio Frequency
TDD	-	Time Division Duplex

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CHAPTER 1

INTRODUCTION

1.1 Project Background

In wireless data communication, RF switch is commonly used in a RF transceiver system to perform Time Duplex Division switching for transmit and receive operation. In RF front end it has filter, mixer, synthesizer, RF switch and other. The project will focus on SPDT design and simulation for WiMAX application at 2.4Ghz. Time Duplex switching means transmitter and receiver shared the same frequency, so SPDT switch was chosen. This will allow the antenna to choose either to transmitting or receiving the signal. Therefore, in early stage of SPDT switch topology or configuration is very important in order to meet wireless digital communication performance. A different SPDT switch configuration will be analyze. In RF switch design PIN diode has been selected as a switch. PIN diode has lower loss and can handle higher power levels than do MESFET. The analysis such as insertion loss, return loss and isolation are simulated in Advanced System Design software and then it will be implemented on FR4 board. Lastly it will be testing by using network analyzer for S parameter measurement.

1.2 Problem Statement

RF switch important to perform Time Duplex switching for transmit or receive signal. Since it shared the same frequency, so RF switch will allow the antenna to choose either to transmit or receive the signal. In RF switch design, different configuration will reflect to different performance. Therefore the suitable SPDT configuration will be chosen for WiMAX application.

1.3 Project Objective

The objective of this project is to simulate and development of RF switch on microstrip printed circuit board for Wimax application at 2.4 GHz.

1.4 Project Scope

The scope of this project is :

- i. Understand the different type of SPDT switch for WiMAX application.
- ii. Determine the topology of SPDT switch.
- iii. Understand the PIN diode as a switch.
- iv. Determine suitable SPDT switch configuration for WiMAX application.
- v. Analyze the selected RF switch topology in ADS software.
- vi. Draw the RF switch layout in ADS software.
- vii. Fabricate the layout on FR board.
- viii. Developed RF switch prototype and test the prototype by using network analyzer for S parameter measurement.

CHAPTER 2

LITERATURE REVIEW

Chapter 2 will discuss precisely about the information and theory relates to this project and also the overview of major component involved. The literature reviews will start with reviewing the RF switches types, classification and functions. Further on, the RF switch will be design based on the types, function and requirements of WiMAX system. The design that has been chosen will be stated at the end of this chapter.

2.1 RF Switch

RF switch is commonly used in a RF transceiver system to perform Time Duplex switching for transmit and receive operation. In RF front end it has filter, mixer, synthesizer, RF switch and other. There is much type of switches known as reflective and non-reflective. Examples of the reflective type are single-pole single-throw, single-pole double-throw and single-pole four-throw. This means when this entire switch is closed between ports In and Out 1, port Out 2 is not connected or it is open and any signal appearing at this port will be reflected. The reflective switch configurations provide lower insertion loss than non-reflective switch topologies. For WiMAX application RF switch is located in the RF front-end in WiMAX structure. RF switch is reacting as the switch for transmit or receive signal in WiMAX application. This project will use Single Pole Double Throw (SPDT) switch type of the RF switch. This SPDT switch has three poles where the single pole is connect to the antenna while the double throw will connect to the receiver and transmitter. This type of switch has been chosen because the system performs Time Division Duplex. This type of switch will allow the

antenna to choose either to transmitting or receiving the signal. The configuration can be divided into three categories such as series, shunt and series-shunt. For this project, series and series shunt configuration are chosen.

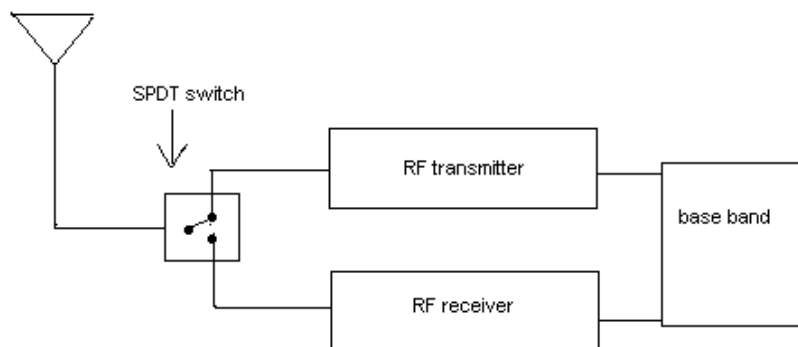


Figure 2.1: SPDT switch in RF transceiver system

In this project, switching parameter or S-parameter is the main character that must be considered. Insertion loss is defined as the ratio of the power delivered to the load on the “ON” state of the ideal switch to the actual power delivered by the practical switch, in the ON state. It is usually expressed in decibels and is a positive quantity. For isolation, it can be defined as the ratio of the power delivered to the load for an ideal switch in the ON state to the actual power delivered to the load when the switch is in the “OFF” state. This also expresses in decibels and is a positive quantity.

2.2 WiMAX

WiMAX, meaning Worldwide Interoperability for Microwave Access, is a telecommunications technology that provides wireless transmission of data using a variety of transmission modes, from point links to portable and fully mobile internet access. The technology provides up to 10 M bit/s broadband speed without the need for cables. The technology is based on the IEEE 802.16 standard (also called Broadband Wireless Access). The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The

forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL".[3]

In WiMAX structure, there is RF front-end that use a RF switch. WiMAX use RF switch because it use a time division duplex (TDD). Time-division duplexing (TDD) is the application of time-division multiplexing to separate outward and return signals. It emulates full-duplex communication over a half-duplex communication link. Time-division duplex has a strong advantage in the case where there is asymmetry of the uplink and downlink data rates. As the amount of uplink data increases, more communication capacity can be dynamically allocated, and as the traffic load becomes lighter, capacity can be taken away.[3]

The requirements for RF switch to become a good switch in WiMAX application at 2.4GHz are:

- i. Have high isolation greater than 11dB
- ii. Have a great insertion loss while transmit or receive mode less than 1dB.
- iii. High linearity
- iv. Can handle high temperature
- v. High power for transmit mode[2]

2.3 Application of RF switch

This SPDT switch is suitable for Customers Premises Equipment (CPE) such as:

- i. Wireless Access Point
- ii. Wireless Router
- iii. Wireless Gateway

For WiMAX, Wi-Fi, HypperLAN, and other standards that operating at 2.4 GHz.

2.3.1 Wireless Access Point

In computer networking, a wireless access point (WAP) is a device that allows wireless communication devices to connect to a wireless network using Wi-Fi, Bluetooth or related standards. The WAP usually connects to a router, and can relay data between the wireless devices (such as computers or printers) and wired devices on the network.[7]

2.3.2 Wireless Router

A wireless router is a device that performs the functions of a router but also includes the functions of a wireless access point. It is commonly used to allow access to the Internet or a computer network without the need for a cabled connection. It can function in a wired LAN (local area network), a wireless only LAN, or a mixed wired/wireless network. Most current wireless routers have the following characteristics:

- i. LAN ports, which function in the same manner as the ports of a network switch.
- ii. A WAN port, to connect to a wide area network, typically one with Internet access. External destinations are accessed using this port. If it is not used, many functions of the router will be bypassed.
- iii. Wireless antennae. These allow connections from other wireless devices (NICs (network interface cards), wireless repeaters, wireless access points, and wireless bridges, for example), usually using the Wi-Fi standard. [8]

2.3.3 Wireless Gateway

A wireless gateway is a computer networking device that routes packets from a wireless LAN to another network, typically a wired WAN. Wireless gateways combine the functions of a wireless access point, a router, and often provide firewall functions as well. [9]

2.4 PIN diode

The most important property of the PIN diode is the fact that it can, under certain circumstances, behave as an almost pure resistance at RF frequencies, with a resistance value that can be varied over a range of approximately 1Ω to $10\text{ K}\Omega$ through the use of a DC or low frequency control current. When the control current is varied continuously, the PIN diode is useful for leveling and amplitude modulating an RF signal. When the control current is switched “on” and “off” or in discrete steps, the device is useful for switching, pulse modulating, attenuating, and phase shifting of an RF signal. In addition, the PIN’s small size, weight, high switching speed, and minimized parasitic elements make it ideally suited for use in miniature, broadband RF signal control components. This application note describes the important properties of the PIN diode and illustrates how it can be applied in a variety of RF control circuits. [10]

2.4.1 Characteristics of the PIN Diode

A PIN diode is a silicon semiconductor consisting of a layer of intrinsic (high resistivity) material of finite area and thickness which is contained between highly doped p and n type material. When the diode is forward biased, charge is injected into the intrinsic or “I” region. This charge consists of holes and electrons which have a finite lifetime before recombination. The density of charge in the intrinsic region and its